

The following is a point-to-point response to the reviewer's comments. We have studied comments carefully and have made correction which we hope meet with approval. Revised portion are marked in red in the revised paper.

### **Reviewer #1**

This study makes an extensive study of the global trends of aerosol optical depth during more than 30 years, with an emphasis on the quantitative estimation of the different weights of emission and meteorological factors in the inter-decadal changes. Different aerosol optical depth sources have been employed, such as satellite derived (MODIS and MISR), ground based (AERONET and CARSNET) and reanalysis (MERRA-2). 12 Regions of Interest were defined, using more than 400 ground stations. The method employed for the derivation of the different weights is based on a stepwise multiple linear regression model, further completed with the Lindeman, Merenda and Gold method to quantitatively evaluate the contribution of each driving factor. The objective of the paper is challenging, implying the use of good quality and large databases. The methods used are complex and recognised by the international community. The validation made in the first part of the study important, given that MERRA-2 performance on a global scope was not assessed before. The results reached are of utmost importance, with adequate references to individual regional results that are complementary and support the conclusions. The paper is well written, with very few and minor mistakes; no flaws detected on the English grammar or style.

**Response:** Thank you for your positive comments on our article. We have revised it in accordance with your comments or suggestions. For detailed revisions, please refer to the following sections

### **Comments**

1. Abstract, line 32: I would change the "in-situ" measurements with "ground-based measurements", even if it is not incorrect.

**Response:** According to the reviewer's good suggestions. The word "in-situ" has been changed to "ground-based".

2. Line 129: Earth system?

**Response:** According to the reviewer's good suggestions. The word "the Earth system" has been changed to "the Earth-atmosphere system".

3. Lines 180 -183: The uncertainty estimation is based on Level 2 data, but this analysis uses Level 3 data. Please consider using Level 3 uncertainty estimations such as Ruiz-Arias et al. (2013): J. A. Ruiz-Arias, J. Dudhia, C. A. Gueymard, and D. Pozo-Vazquez. Assessment of the Level-3 MODIS daily aerosol optical depth in the context of surface solar radiation and numerical weather modeling. Atmos. Chem. Phys., 13, 675–692, 2013. doi:10.5194/acp-13-675-2013

**Response:** Thanks for pointing this out. Unfortunately, we did not use the reference mentioned by the reviewer because the C5.1 version was evaluated in this paper,

while the C6.1 version was used in our study. Here, we refer to an assessment of the latest C6.1 L3 data. We have described the accuracy of L3 and added references. Detailed revisions are as follows:

“The average MAE (RMSE) of the Level 3 MODIS/Terra DTB monthly AOD data have been estimated to be about 0.075 (0.120) over land (Wei et al., 2019).”

**Reference:**

1. Wei, J., Peng, Y., Guo, J. and Sun, L.: Performance of MODIS Collection 6.1 Level 3 aerosol products in spatial- temporal variations over land, Atmos. Environ., 206, 30–44, doi:10.1016/j.atmosenv.2019.03.001, 2019

4. Line 185: earth?

**Response:** According to the reviewer’s good suggestions. The word "the Earth atmosphere" has been changed to "the Earth’s atmosphere".

5. Line 201: I think it should be written "AERONET and CARSNET"

**Response:** Corrected

6. Line 235-236: other independent meteorological fields instead of MERRA-2?

**Response:** First, MERRA-2 meteorological field has similar or even better performance than other reanalysis data, because it is the first reanalysis dataset that assimilates aerosol satellite observation data and considers aerosol radiation feedback. Secondly, considering the difference of spatial resolution between MERRA-2 AOD and other reanalysis meteorological fields (such as NECP, JRA, etc.), if other reanalysis meteorological fields are used, the conclusion may be affected. Therefore, we believe that the MERRA-2 meteorological field is suitable for this study.

7. Line 237: etc

**Response:** Corrected

8. Line 343: AERONET

**Response:** Corrected

9. Line 347-348: I don’t understand this, based in figure b4. Should be "lower" instead of "greater" than 0.1 and 0.05, respectively?

**Response:** Thanks for pointing this out. The word "greater" has been changed to "lower".

10. Line 356: there clear?

**Response:** Thanks for your thoughtful suggestion. The word "Europe" has been changed to "southern Europe"

11. Lines 488-490: any reason to explain the change?

**Response:** Thanks for your thoughtful suggestion. We have added some appropriate explanations and reference for this sentence, as shown below:

“This shift may be attributed to the fact that MERRA-2 did not assimilate any land-based AOD observations before 1999, which made it difficult for the model to simulate the monthly variation of regional AOD (Gelaro et al., 2017; Buchard et al., 2017).”

**Reference:**

1. Gelaro, R., McCarty, W., Suárez, M. J., Todling, R., Molod, A., Takacs, L., Randles, C. A., Darmenov, A., Bosilovich, M. G., Reichle, R., Wargan, K., Coy, L., Cullather, R., Draper, C., Akella, S., Buchard, V., Conaty, A., da Silva, A. M., Gu, W., Kim, G. K., Koster, R., Lucchesi, R., Merkova, D., Nielsen, J. E., Partyka, G., Pawson, S., Putman, W., Rienecker, M., Schubert, S. D., Sienkiewicz, M. and Zhao, B.: The modern-era retrospective analysis for research and applications, version 2 (MERRA-2), *J. Clim.*, 30(14), 5419–5454, doi:10.1175/JCLI-D-16-0758.1, 2017.
2. Buchard, V., Randles, C. A., da Silva, A. M., Darmenov, A., Colarco, P. R., Govindaraju, R., Ferrare, R., Hair, J., Beyersdorf, A. J., Ziemba, L. D. and Yu, H.: The MERRA-2 aerosol reanalysis, 1980 onward. Part II: Evaluation and case studies, *J. Clim.*, 30(17), 6851–6872, doi:10.1175/JCLI-D-16-0613.1, 2017.

**12.** Lines 824: the term "wind speed" was used in the previous paragraph but here WS is used instead. Perhaps using wind speed would be fine, given that the text includes many acronyms

**Response:** Corrected.